UNITED STATES PATENT OFFICE.

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METHOD OF REDUCING ORES.

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To all whom it may concern:

Be it known that I, FREDERICK M. BECKET, a subject of the King of Great Britain, residing at Niagara Falls, in the county of Niagara and State of New York, have invented certain new and useful Improvements in Methods of Reducing Ores, of which the following is a specification.

This invention contemplates the employment as a reducing agent for ores, and more particularly for the oxid ores of such refractory metals as chromium, tungsten, molybdenum and vanadium, of certain borids or alloys or compounds of boron, and particularly the borids of the alkali earth metals, as calcium borid, for example, and carbon borid. The use of these reducing agents presents particular advantages in the production of metals or alloys which are required to be low in carbon and silicon, and more particularly in such cases where the presence of a small proportion of boron in the final product is either advantageous or unobjectionable. For example, chromite may be directly reduced by an alloy of calcium and boron which may be either a borid of calcium or an alloy containing either calcium or boron in excess, the resulting product being a ferro-chromium which is low in carbon or substantially free therefrom. In case the alloy employed contains also such reducing agents as carbon or silicon, or other impurities or constituents capable of exerting a reducing effect upon the constituents of the ore under the furnace conditions, these impurities or constituents are taken into account in the preparation of the charge. Compounds, and more particularly oxidized compounds, of other refractory metals as tungsten, molybdenum and vanadium may be similarly treated. Similarly, chromite or other ore of a refractory metal may be reduced by carbon borid, both elements of the reducing agent being oxidized in course of the operation. Although carbon is present in considerable proportion in the reducing agent, it is found that it shows but little tendency to enter into and contaminate the product; this is probably because the carbon of the initial charge exists in a combined state and is therefore not readily dissolved or absorbed by the portions of the metal first reduced.

The reducing agents may be used in substantially the proportion required to combine with the oxygen of the charge, or in somewhat smaller or greater proportion, depending upon the character of the product desired and whether boron is a desirable or non-injurious constituent thereof. In cases in which it is desired to produce a product low in boron, the ore is preferably employed in excess; on the other hand, where boron is unobjectionable or is a desirable constituent of the product, a somewhat higher efficiency of operation may be secured by using a slight excess of the reducing agent or such excess as may correspond to the desired boron content of the product. The operation is facilitated by the presence in the charge of a base capable of uniting with the oxid of boron produced. In case calcium borid is used as a reducing agent, this base is provided wholly or in part by the oxidation of the calcium, supplemented by such bases as may be normally present in the ore. Most commercial chromites contain from 8 to 15 per cent. of alumina and a similar proportion of magnesia and to the extent of their presence these serve the purposes of a basic flux. In case of ores free from basic constituents, or in case of the deficiency of such constituents, a suitable basic flux, as lime, is added as required, the object being the formation of a slag having a suitable fusing point and a proper degree of fluidity at the working temperature of the furnace. Obviously, an acid flux may be added should the constitution of the charge require it for the production of a proper slag.

The reduction is preferably carried out in an electric furnace, and where a fused metallic product low in boron is required, the use of the electric furnace, or of a furnace capable of affording a like high temperature, is probably essential. The electrodes may be of carbon, or of a refractory metal or alloy suitably water-cooled, in accordance with the proportion of carbon permissible in the product. The lining of the furnace should be chosen with reference to the composition of the slag to resist so far as possible its corrosive effect. In case very low percentages of carbon are not required, the furnace may have a hearth or lining of carbon. The operation is preferably substantially continuous in character, the charge materials being supplied as required and the molten products tapped from the furnace. The slags are advantageously utilized for the production of borates, as for example the borates of the alkali metals, or they may be reduced by carbon in a separate operation. In the lat-

ter case the boron constituent is recovered, usually in the form of an alloy with the other reducible constituents of the slag, as for example, an alloy of boron with silicon, or with silicon and calcium, often in conjunction with a considerable proportion of the metal, as chromium, etc., originally reduced; in this form the boron may be repeatedly utilized for the reduction.

By the expression "refractory metals" occurring in certain claims, I mean such metals as require the application of heat to the charge to maintain the reacting temperature for their reduction by boron or alloys or compounds of boron with production of a reduced metal free or substantially free from the unoxidized reducing agent, the reaction not being self-propagating in character.

I claim:—

1. The method of reducing ores of refractory metals, which consists in smelting a charge containing such ore and a borid, while maintaining therein a temperature sufficient to secure substantial elimination of the boron from the reduced product.

2. The method of reducing ores of refractory metals which consists in smelting a charge containing such ore and calcium borid.

3. The method of reducing ores of refractory metals, which consists in smelting a charge containing such ore and a borid, thereby producing a metal or alloy and a slag containing boron, and smelting said slag to recover boron therefrom.

4. The method of reducing ores of refractory metals, which consists in smelting a charge containing such ore, a borid and a basic flux, thereby producing a metal or alloy and a slag containing boron, and smelting said slag to recover boron therefrom.

5. The method of reducing ores of refractory metals, which consists in electrically smelting a charge containing such ore and a borid.

6. The method of reducing ores of refractory metals, which consists in electrically smelting a charge containing such ore and a borid of an alkali earth metal.

In testimony whereof, I affix my signature in presence of two witnesses.

FREDERICK M. BECKET.

Witnesses:

GEORGE C. FURNESS,

J. N. DEINHARDT.